ENERGY &
TELECOMMUNICATIONS
INTERIM COMMITTEE 2019-2020

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NORTHWESTERN ENERGY 2019 ELECTRICITY SUPPLY RESOURCE PROCUREMENT PLAN

COMMENTS BEFORE
THE MONTANA PUBLIC SERVICE COMMISSION
SUBMITTED May 4, 2019

GB Energy Park, LLC

I. EXECUTIVE SUMMARY

The following comments are offered by GB Energy Park LLC (GBEP), developer of the Gordon Butte Closed Loop Pumped Storage Hydro Project (Gordon Butte PSH), in response to the NorthWestern Energy 2019 Electricity Supply Resource Procurement Plan's (2019 Plan) assessment of the future power supply needs of NorthWestern Energy (NWE). GBEP is a single-purpose subsidiary of Montana-based Absaroka Energy Development Group, LLC (Absaroka).

GBEP agrees that given the changes in the electricity markets, additional flexible capacity will be necessary to maintain the long-term health, sustainability, and serviceability of NorthWestern's system. Careful analysis of the 2019 Plan is an important step in ensuring that NWE's customers are provided with the optimum combination of resources to deliver reliable and cost-effective services and ensuring the long-term resiliency of the NorthWestern system.

GBEP offers the comments, observations, questions, and concerns contained within this document to assist NorthWestern in refining the 2019 Plan and subsequent Request For Proposals (RFP), and to more appropriately evaluate and acquire the resources that will best meet their needs.

In general, GBEP's comments on the 2019 Plan can be briefly summarized as follows:

- GBEP does not agree with the conclusion that gas-fired generation resources will provide the most reliable, cost-effective solution to the capacity and flexibility needs identified in the 2019 Plan.
- GBEP engaged an outside expert (see Attachment A) to conduct detailed modeling and analysis of its Gordon Butte Pumped Storage Hydro Project (Gordon Butte PSH) compared to existing rate-based NorthWestern assets (Colstrip 4, Hydro Dams, Spion Kop, and Dave Gates Generation Station). The results show that the advanced pumped storage facility is the **lowest cost choice** for the utility.[1]

Item	DGGS	SPION	Colstrip	Hydro	Gordon Butte
Total Revenue	$29,244,149.00	$11,683,771.0	$77,680,104.00	$142,759,244.00	$72,488,341.54
Capacity [MW]	150	40	222	448	400
Revenue $/kW-yr	$194.96	$292.09	$349.91	$318.66	$181.22

[1] Acelerex. Gordon Butte Rate Base Analysis. May 2019. NOTE: Carbon not considered in analysis. CV for Acelerex available in Attachment A

- The modeling and processes used to create the 2019 Plan **do not adequately measure and/or quantify** the full value and benefits of energy storage assets like the Gordon Butte Pumped Storage Hydro Project. Benefits beyond providing energy – such as grid stability, transmission services, stackable ancillary services, system optimization, and flexible capacity. **This is of particular concern because as NorthWestern states in the 2019 Plan, "The model and modeling framework used in this plan will be used to evaluate proposals submitted during competitive solicitations and will also be used to evaluate opportunities purchases."**
- PSH with modern equipment can provide the **regulation duty at a lower cost** than the current portfolio of DGGS, Basin Creek, Colstrip Unit 4, Cochran, Ryan, Mystic, Thompson Falls and other contracted units.
- These existing units should be utilized as energy generating assets – allowing them to operate more reliably and efficiently with a resulting benefit to ratepayers.
- The Gordon Butte PSH facility has been designed to permit an offtaker, such as NorthWestern, to acquire or contract for a portion of the facility that would best suit their needs.
- There are **unanalyzed costs and risk associated** with the development of new gas in the 2019 Plan that have not been identified – development of linear facilities (pipe and transmission lines) for gas will be difficult and potentially unfeasible.
- ***Risks associated with future carbon assets*** should be included in the analysis for new resources and must be assessed in an even and fair manner.
- Highly-flexible, utility-scale, long-duration energy storage facilities, like Gordon Butte PSH, require specific siting criteria and are difficult and time-intensive to develop. NorthWestern Energy and its customers **can capitalize on the unique opportunity** to acquire an asset that will have positive cost/benefits to Montana's ratepayers.

ABSAROKA ENERGY LLC

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II. Introduction

These comments are offered by GB Energy Park LLC (GBEP), developer of the Gordon Butte Closed Loop Pumped Storage Hydro Project (Gordon Butte PSH), in response to the NorthWestern Energy 2019 Electricity Supply Resource Procurement Plan's (2019 Plan) assessment of the future power supply needs of NorthWestern Energy (NorthWestern). GBEP is a single-purpose subsidiary of Montana-based Absaroka Energy Development Group, LLC (Absaroka).

NorthWestern has offered to electricity consumers and the Montana Public Service Commission (PSC) a plan for an energy resource future, recently filed as the NorthWestern Energy 2019 Electricity Supply Resources Procurement Plan (2019 Plan). The 2019 Plan clearly articulates a future need for additional flexible capacity in the NorthWestern system over the near term. Throughout the Draft 2019 Plan, NorthWestern highlights the importance of new flexible capacity resources[2] to provide the peaking capacity, INC and DEC (ramping), renewable energy integration, and to cover its resource adequacy requirements in order to join the Western Energy Imbalance Market (EIM).[3]

In general, GBEP agrees with this assessment of NorthWestern's future resource needs. As the Pacific Northwest Region shifts away from baseload thermal generation to a mix that will inevitably focus on increasing penetrations of wind and solar, grid operators will need highly flexible, long-lived, fast-ramping platforms that will provide flexible capacity to keep the system reliable, resilient, and affordable.

However, GBEP does not agree with 2019 Plan's conclusion the addition of gas-fired generation is the best and most cost-effective solution for addressing future capacity and flexibility needs.

Throughout the electric utility industry, forward-looking utilities are evolving away from a resource portfolio dominated by conventional generation resources toward more flexible assets,

[2] In the 2019 Plan, NorthWestern identifies flexible capacity as: "Resources that can be dispatched on-demand to ramp up and ramp down relatively quickly...Flexible capacity is needed to match generation to short-term variations in load. Additionally, variable energy resources like wind and solar require dispatchable energy resource to balance the energy grid and assure reliability." (2019 Plan 1-4)

[3] In the Western EIM, NWE will have to pass hourly resource adequacy tests to cover its energy trading in the market. By participating in a 15-minute market, fast ramping resources will be highly valuable to the utility. "While the individual BAs retain their reliability responsibility, EIMs have resource sufficiency requirements that obligate participating BAs to carry enough capacity to meet their own internal needs. These requirements are designed to keep a participating BA from entering an hour in a capacity- or energy-short position and relying on the EIM to meet its load-serving obligations. Participation in an EIM helps make efficient use of resources, but it does not reduce a BA's need for capacity. Depending on the specifics of the resource sufficiency requirement, participation could drive the need for additional capacity."(2019 Plan 5-2)

including energy storage, as a critical component of a least-cost resource mix.[4] Modern, fast-responding Pumped Storage Hydro (PSH) is recognized as the most capable, cost-effective, and proven utility-scale energy storage technology in the world.[5] It is also capable of providing the resource needs for capacity, flexibility, ramping and dispatchability that NorthWestern identifies in the 2019 Plan.

GBEP respectfully proposes that Gordon Butte PSH be considered as a robust flexible capacity solution for NorthWestern's system. GBEP believes that, if accurately evaluated, the project will prove to be a **least cost solution and offer a wider range of operational capabilities** than the resources currently proposed in the 2019 Plan.[6]

GBEP acknowledges that under current statute, it is not feasible for the utility to consider both the transmission and generation benefits of large-scale energy storage in the 2019 Plan; however, we feel that it would be highly useful for NorthWestern and its ratepayers to do so. GBEP is willing to work with the utility and the Public Service Commission (PSC) to explore ways that the full value of pumped storage hydro can be demonstrated through a comprehensive analysis of both transmission and generation benefits.

Gordon Butte PSH received an Original Hydropower License by the Federal Energy Regulatory Commission (FERC) in December of 2016, is fully permitted, and has finalized its engineering design. By the time the Draft 2019 Plan is completed, the Project will be construction-ready and will be able to be placed in service in 2024 or soon thereafter. This timeline makes Gordon Butte PSH a viable project that fits neatly into NWE's resource acquisition timeline laid out in their planning document.

New electric resources typically have long life spans (30 years or more) with significant cost considerations for electricity consumers. As NWE evaluates the procurement of new generation into its resource portfolio, a thoughtful, inclusive, and objective review of all options available to NWE will serve to ensure the best resource portfolio to meet NWE's future capacity and flexibility needs. We request that the PSC carefully consider the full range of services and contributions that Gordon Butte PSH offers for Montana's energy future.

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[4] https://www.greentechmedia.com/articles/read/pacificorps-march-from-coal-toward-clean-energy-alternatives?utm_medium=email&utm_source=Daily&utm_campaign=GTMDaily#gs.9cg4sq

[5] http://www.nwhydro.org/wp-content/uploads/events_committees/Docs/2016_Pumped_Storage_Workshop_Presentations/4%20-%20Patrick%20Balducci.pdf

[6] Acelerex. *Gordon Butte Rate Base Analysis.* May 2019. NOTE: Carbon not considered in analysis. CV for Acelerex available in Attachment A

III. Project Overview

Figure 1. Artist rendering of the Gordon Butte PSH Project

GBEP is currently developing the Gordon Butte Closed Loop Pumped Storage Hydro facility in Meagher County. The Gordon Butte PSH project is:

- **CONSTRUCTION READY:** The Gordon Butte PSH has received its 50-year hydropower license from FERC, completed its NEPA environmental review (Environmental Assessment with Finding of No Significant Impact), completed all the necessary permitting, secured the land and water (Montana State issued Water Right), finalized its engineering design, and has engaged the Engineering, Procurement and Construction (EPC) team that will build the project.[7]
- **UTILITY-SCALE:** <u>NorthWestern can contract for the portion of the Project that best fits its needs</u>. The facility has been designed to accommodate multiple operators. Should NorthWestern acquire or contract for a share of the Project, there are multiple ways that the remaining capacity could be allocated. The facility will have three-unit pairs. Each pair will include a separate pump and turbine, each with a dedicated 134 MW motor and a 134 MW generator, respectively, for an installed capacity of 400 MW with 3,400 MWh

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[7] The major milestones that have been achieved to date: Land Agreement in Place for Project and Easements, MT State Issued Water Right Permit Obtained, 401 Water Quality Certification Waived – No Water Discharge, NEPA Environmental Assessment – Finding of No Significant Impact, Front End Engineering Design Completed, FERC License Issued (P-13642), FERC License Article Compliance Current, Equipment Selection and Design (General Electric Renewable Energy), Key Subcontractors and Vendors, EPC Team (Ames Construction, Black & Veatch), Interconnect Feasibility and System Impact Studies Completed

hours of storage – or 8.5 hours at continual maximum discharge for 400 MW. Each unit pair will have the capability to be operated independently from one another.

- **FAST-ACTING:** The pump/turbines will be Quaternary units configured in a hydraulic short-circuit (further discussed in Section VI below). This will allow the facility to operate pumps and turbines simultaneously and switch seamlessly from pumping to generating mode. The facility will be able to ramp at an estimated rate of 20+ MW/sec in either direction.[8]

- **FLEXIBLE**: The operational versatility of the units will allow NorthWestern to utilize the facility for flexible capacity, as well as a wide-ranging suite of grid operation services. This suite includes:
  - Peaking capacity
  - Energy storage
  - Energy arbitrage
  - Integration and firming of existing and future renewables
  - Ancillary services, including
    - Regulation Up
    - Regulation Down
    - Load-following
    - Spinning and non-spinning reserves
    - Black start
    - Voltage Control
    - Frequency Control
    - System Inertia
    - INC / DEC

The Gordon Butte facility is equivalent to a Swiss Army knife - able to provide multiple service from a single platform.

IV. Key Conclusions from the NWE 2019 Plan

There are many overarching conclusions from NWE's analysis provided in the 2019 Plan that GBEP agrees with, including the following:

- The 2019 Plan appropriately focuses on the addition of flexible capacity resources. The 2019 Plan identifies a current capacity deficit of **645 MW** and is forecast to grow to **725 MW** by 2025 (1-3).

[8] The GBEP equipment configuration has earned attention of the hydropower industry and was picked up by the U.S. Department of Energy for the analysis of grid support and economic benefits based on its fast-acting capabilities. https://www.energy.gov/eere/articles/pumped-storage-projects-selected-techno-economic-studies

- NWE is right to focus on the addition of new assets that are capable of meeting the utility's peaking needs.
- NWE is right to take steps to wean itself off of bilateral transactions for its capacity deficits.
- Joining the EIM is a good idea. To participate, NWE will need to demonstrate, on a day-ahead basis, the ability to meet its load, ramps, and uncertainty throughout the day. This requirement makes the addition of flexible capacity essential.
- Managing transmission congestion with flexible resources is important and therefore transmission benefits should be taken into consideration in the evaluation of new resources.

While GBEP strongly agrees that NorthWestern will need to acquire additional resources to satisfy their demonstrated needs for capacity and flexibility. The 2019 Plan identifies numerous needs that the advanced pumped storage hydro will be a cost-effective and ideal resource to address (excerpts from the 2019 Plan provided in italics):

- **Peaking resources** – Gordon Butte PSH will be able to provide up to 3,400 MWh of peaking generation in addition to its other ancillary and transmission services. To put this another way, gas peakers can only provide peaking energy, Gordon Butte PSH provides this same service as a part of its "stacked" capabilities.
- "Without new peaking capacity, the market exposure will increase to about 725 MW by 2025 (including reserve margins)." (2019 Plan. Page 1-3)
- **Flexible capacity** – Above and beyond peaking, Gordon Butte PSH will supply a large amount of flexible capacity and provide fast-ramping (20+ MW/sec) operational capability to quickly respond to the minute-to-minute changes in generation and load – keeping the transmission system in balance. Below are a few of the important future needs and requirements identified in the 2019 Plan:
- "Resources that can be dispatched on-demand to ramp up and ramp down relatively quickly...Flexible capacity is needed to match generation to short-term variations in load. Additionally, variable energy resources like wind and solar require dispatchable energy resource to balance the energy grid and assure reliability." (2019 Plan. Page 1-4)
- "Navigant concluded that NorthWestern's system should have a baseline of 120 MW of INC, 155 MW of DEC, and regulation capacity of +/-25 MW (i.e., 50 MW of total regulation comprised of +25MW and -25 MW)." (2019 Plan. Page 3-8)
- "Dispatchable capacity is important in that it allows NorthWestern to integrate variable resources including renewable generation and follow load within its system while maintaining the reliability BAL-001-2 NERC requirements for the Balancing Authority." (2019 Plan. Page 4-12)

- **Storage for surplus off-peak energy** – Unlike gas-fired resources, energy storage allows grid operators to effectively and efficiently optimize and manage their resources by time-shifting low-cost energy (energy that is currently dumped on the market or curtailed) to times of the day that energy is most valuable.
- "During heavy load hours, the current resource portfolio produces a little less energy (on a monthly basis) than customers consume. During light-load hours, the portfolio produces more energy (on a monthly basis) than customers consume. Excess energy is sold into the wholesale electricity market at lower prices, often lower than the cost of energy being produced. This is done because NorthWestern must take the energy from variable resources like wind even if it is not needed, and the hydro and thermal resources like Colstrip have minimum production levels or must be operating in order to respond to changes in wind generation or loads." (2019 Plan, Page 1-5)
- **On-system resource to avoid transmission import risk** – Gordon Butte PSH will interconnect to the Colstrip Transmission System – at a new substation located approximately 5.5 miles south of the Project – the backbone of NorthWestern's system. This location makes it an ideal resource for the utility to optimize both its intra and interstate transmission flows, as well as utilize the fast-acting ancillary services to maintain the reliability and resiliency of its grid.

  "During the most critical periods, NorthWestern Energy relies heavily on imports into our system in order to meet customer needs. The transmission system in Montana was constructed around, and is heavily reliant on, the generating resources and their location, including the entire Colstrip Power Plant. The retirement of Colstrip units will impact NorthWestern Energy's ability to import sufficient power to meet peak energy demands." (2019 Plan, Page 1-9)
- **Gordon Butte PSH can be divided up into capacity slices** – In their draft 2019 Plan, NorthWestern has indicated that they will use a staged multi-year approach to add 200 MW of capacity per year from 2022 to 2025 (2019 Plan. Page 1-13). While the total nameplate capacity of the Gordon Butte PSH is 400 MW, that does not mean that a single offtaker will have to purchase or contract for the entire facility. An offtaker like NorthWestern will be able to purchase and/or contract for the amount of capacity it needs – be it 133 MW, 266 MW, all the way up to 400 MW. In this scenario, GBEP would then offer the remaining capacity to other utility or merchant customers.[9]

As we discuss in detail in Section VII below, advanced PSH is the most mature, cost effective, utility-grade flexible capacity and storage resource available, and should be considered for

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[9] The power plant controls have been designed to incorporate GE's Digital Twin software technology. https://www.ge.com/digital/sites/default/files/download_assets/The-Digital-Twin_Compressing-Time-to-Value-for-Digital-Industrial-Companies.pdf

addressing NWE's capacity needs.[10] The Gordon Butte PSH project has been developed for integration into the regional power system to provide the very capabilities NWE has identified that its system will require in the future.

V. Concerns/Questions with 2019 Plan

Concern: The 2019 Plan results in a huge bet on a single resource type - gas fired generation.

- If resource acquisitions follow what is laid out in the 2019 Plan, approximately 65% of NorthWesterns's peak load contribution will come from gas. (Table 4-1, Page 4-7: peak contributions + 800 MW new gas.)
- NorthWestern's gas transportation system will need to be expanded to accommodate the new facilities. Furthermore, it is understood that the system will be unable to deliver to the new gas units on extreme cold days,[11] as is currently the case at the Dave Gates Generation Station (DGGS), requiring the utility to utilize backup fuel (identified at the DGGS RICE addition as diesel fuel).

  The 2019 Plan includes cost estimates for the additional linear infrastructure needed for RICE additions at DGGS, "...the estimate included $2.5M for upgrades to the existing natural gas delivery system and $1.5M for electrical transmission interconnection work including possible relocation of transmission lines inside of the DGGS facility."(2019 Plan. Page 7-21)

  Question: When analyzing the costs of developing new gas-fired generation assets (other than DGGS) were additional costs for the construction and/or expansion of the natural gas delivery system and transmission system included in the capital cost calculations? If not, what would those costs be?

  Question: Were additional O&M costs assessed for operating the proposed gas plants with diesel and/or alternative fuels? If yes, what specific information was considered?

  Question: The development of new linear facilities (both pipelines and transmission) carry inherent risks, were these considered in the economic evaluations?

Concern: It is not clear what type of generating, reliability, shaping, or firming resource NWE energy is seeking.

- There seems to be a focus on meeting peak demands.

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[10] http://www.nwhydro.org/wp-content/uploads/events_committees/Docs/2016_Pumped_Storage_Workshop_Presentations/4%20-%20Patrick%20Balducci.pdf

[11] *"Currently, gas-fired generation on the system operates utilizing interruptible gas transportation arrangements. As a result, during the coldest days of the year, gas supply to electric generation is subject to curtailment."(6-19)*

- There also seems to be a focus on acquiring more generation to meet reserve requirements, limit exposure to market availability, and be able to meet its own loads while participating in EIM.
- There is also discussion of flexible capacity, with no clear definition of the physical parameters of what is meant by flexible capacity.
- Discussed within the plan is problems with wind and solar not be dispatchable when needed. It is not clear how NWE is going to address integrating, shaping, and scheduling wind and solar to align more with the needs of NWE.

  Question: It is discussed that flexible capacity is tied to meeting INC and DEC needs, how does this differ from the other needs above?

  Question: Is NorthWestern looking for a peaking facility that can be used a limited number of hours per year? Or being dispatched to meet peaking needs?

Concern: The 2019 Plan makes critical assumptions and analytical choices that may favor the all-gas base case.

- The base case includes no carbon cost and the carbon cost sensitivities may not be robust enough to capture the full range of carbon risks.[12] For example, in the past NorthWestern priced in significant carbon risk during the justification of the purchase price for their acquisition of the hydroelectric dams, and then ignored or downplayed carbon risk when acquiring Colstrip 4 and in this 2019 Plan. It appears now that the Montana courts will require this analysis.[13]

  Recently, utility companies throughout the Pacific Northwest are viewing carbon risk, both politically and economically, as a significant factor informing their future resource acquisition decision-making. Table 1 below shows how other Colstrip Utilities are forecasting future carbon pricing in their recent integrated resource plans.

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[12] "To align with PSC direction in D2016.5.39 (QF-1) and D2016.12.103 (MTSUN), NorthWestern is not including a carbon cost in the base case for the 2019 Plan."(9-12)

[13] Vote Solar, Montana Environmental Information Center and Cypress Creek Renewables, LLC and Windata, LLC vs. The Montana Department of Public Service Regulation, Montana Public Service Commission and NorthWestern Corporation and Montana Consumer Counsel. Order vacating and modifying Montana Public Service Commission Order Nos. 7500c and 7500d. April 2nd, 2019

Table 1. Regional Carbon Cost Assumptions

Regional Carbon Cost Assumptions ($/ton)							
	NWE	**NWE High**	**PSE 2017 IRP Mid**	**PGE 2016 IRP Mid**	**PGE 2016 IRP High**	**PacifiCorp 2017 IRP**	**AVISTA 2017 IRP (Colstrip Carbon Cost)**
2018			14.36				
2019			15.37				
2020			16.45				
2021			17.60				
2022			18.82	18.15	22.69		
2023			20.14	18.83	23.59		7.00
2024			21.55	19.51	24.50		9.21
2025		**20.00**	23.06	20.19	25.41	4.75	11.43
2026		**20.83**	24.67	20.87	26.32	6.25	13.64
2027		**21.69**	26.40	21.55	27.22	8.00	15.86
2028	**5.71**	**22.59**	28.25	22.23	31.08	11.00	18.07
2029	**7.11**	**23.53**	30.23	22.91	34.94	12.50	20.29
2030	**9.90**	**24.51**	32.35	23.59	39.02	26.00	22.50
2031	**11.44**	**25.53**	34.62	26.32	42.65	28.00	24.71
2032	**13.04**	**26.59**	37.04	29.04	46.51	29.50	26.93
2033	**14.70**	**27.69**	39.63	31.76	50.36	31.25	29.14
2034	**16.42**	**28.84**	42.40	34.48	54.22	32.00	31.36
2035	**17.48**	**30.03**	45.37	37.21	58.08	37.00	33.57
2036	**18.57**	**31.28**	48.54	39.93	61.93	38.02	35.79
2037	**21.22**	**32.58**	51.93	42.65	65.79		38.00
2038	**22.42**	**33.93**		45.37	69.65		
2039	**23.65**	**35.34**		48.09	73.50		
2040	**24.93**	**36.81**		50.82	77.36		

Question: How should NorthWestern factor in future carbon pricing as they evaluate new resource additions over a 15-year horizon?

Question: In light of the recent District Court ruling in Vote Solar, how will NorthWestern reevaluate future carbon pricing in the final 2019 Plan?[14]

Question: Will current and future laws restricting carbon-based generation in other states affect NorthWestern's ability to utilize gas resources in the EIM? Has this subject been considered by NorthWestern? If so, what inputs were used to address this issue?

Question: Does NorthWestern give any priority to carbon-free assets above and beyond carbon pricing?

Concern: Gas price and carbon price sensitivities are only included for the base case. (Figure 10-3) These sensitivities should be run for all of the resource portfolios in Figure 10-2. This presumably would narrow the gap between the all-gas base case and the other portfolios with non-gas resources.

- The 2019 Plan analysis limits surplus energy sales to 10% of annual load.[15] The 10% surplus sales limit may be disadvantaging other resource portfolios relative to the base case. In particular, the Pumped Hydro Portfolio which includes 200 MW of new wind (an assumption that GBEP does not agree with – see below for more detail).

Question: It's not clear how this criterion is enforced in the model – is it enforced every hour or in aggregate over the year?

Question: If it's over the entire year, does the model stop making surplus sales after the annual limit is met?

Concern: Sensitivities without the surplus sales constraint should be run for all resource portfolios in Figure 10-2. Doing so would likely narrow the gap between the all-gas base case and the other portfolios with non-gas resources.

Question: NorthWestern seemed unconcerned about making additional surplus sales if they acquired additional shares of Colstrip 4, why treat other potential acquisitions the same?

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[14] Vote Solar, Montana Environmental Information Center and Cypress Creek Renewables, LLC and Windata, LLC vs. The Montana Department of Public Service Regulation, Montana Public Service Commission and NorthWestern Corporation and Montana Consumer Counsel. Order vacating and modifying Montana Public Service Commission Order Nos. 7500c and 7500d. April 2nd, 2019

[15] "Market sales were constrained to no more than 10% over annual customer load. This restriction prevents the model from overbuilding resources for the express purpose of selling energy into the market."(10-3)

Concern: NorthWestern's flexible capacity needs may not be adequately represented in the 2019 Plan's hourly PowerSimm modeling.

- The Navigant study that quantifies NorthWestern's flexible capacity needs is described in the 2019 Plan (pages 3-7 to 3-13). The plan also discusses the resources available to meet the flexible capacity needs (see Table 2).[16]

Table 2. 2019 Plan Table 4-3, Percent of Intra-Hour Plant Use For RBC

2017	Basin Creek	Colstrip Unit 4	Cochran Ryan	DGGS	Mystic	Thompson Falls	Contracted	Total
INC	37%	22%	17%	25%				100%
DEC	16%	47%	31%	6%				100%
Spin		19%	51%		10%	18%	2%	100%
NonSpin	4%			96%				100%

- During the recent rate case testimony, NorthWestern described in detail the process NorthWestern goes through each hour to determine how much capacity to set aside for potential INC and DEC needs.[17]
- It is not clear the extent to which this hourly decision process is reflected in the PowerSimm modeling that informs the 2019 Plan.[18]
- NorthWestern's hourly strategy for meeting flexible capacity needs should be modeled in PowerSimm so that the true cost of meeting flexible capacity needs with existing and planned resources is accurately portrayed.

  Question: Did NorthWestern model resources at a higher temporal resolution than one-hour step sizes?

  Question: How does this model differentiate between fast acting resources like PSH (that can ramp in MW per second) and slower reacting resources like natural gas (that ramp in MW per minute)?

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16 NorthWestern's current portfolio has limited capacity that can ramp up within the hour (see Table 4-3). The primary INC capacity comes from Colstrip Unit 4, DGGS, Basin Creek, and some from Cochrane and Ryan dams. Multiple resources in the portfolio can provide DEC, including some QF resources, but the curtailments required for the QF resource to provide DEC typically require compensation that would reflect no monetary loss for the project owners nad it is therefore rarely economic to call on them for this capability."(4-12)

17 Montana Pubic Service Commission. Application for Authority to Increase Retail Electric Utility Service Rates and for Approval of Electric Service Schedules and Rules. (Docket No. D2018.2.12. September 28, 2018) Testimony of Joseph M. Stimatz.

18 "These analyses are performed at an hourly time-step, which provides insight into the unique operating characteristics of renewable resources and the flexibility of dispatchable resources to respond optimally, and rapidly to changing market conditions."(10-1)

Concern: The ability of the current generation assets to provide the amount of DEC represented in the 2019 Plan.

- In the 2019 Plan, Table 4-1 (page 4-7) lists all of the resources that can potentially be used to provide DEC – this totals more than 800 MW. However, this table overstates the DEC that is usually available for many reasons. The thermal units (200 MW of gas + 100 MW of Colstrip) must be on-line and producing at maximum output to provide the full amount of DEC shown. The renewables (more than 400 MW) must be at full output and NorthWestern must have a contractual right to curtail them to provide the DEC amounts shown. If hydro units are at capacity, NorthWestern would have to be willing to spill valuable no-cost energy to provide DEC.

  Question: What specific operational assumptions were used to analyze the current portfolio's ability to address DEC?

Concern: The PSH portfolio may not fully capture the flexible capacity value provided by advanced PSH, especially Gordon Butte PSH.

- Were NorthWestern to acquire a PSH resource like Gordon Butte, the asset would serve as: 1) a low-cost source of flexible capacity; 2) a resource to provide regulation (this would free up capacity in DGGS for other purposes); 3) the primary source of INC and DEC; 4) a minute-to-minute integration and optimization resource for renewable generation; and 5) storage for low cost surplus energy (hydros and baseload thermal generation). It does not appear that the full range of PSH's operational characteristics, flexibility, or stacked value stream were accounted for in the PSH portfolio.
- Ascend Analytics, the company that owns the PowerSimm modeling platform, also owns BatterySimm. This is a modeling platform specifically designed to analyze energy storage technologies.[19]

  Question: Has NorthWestern utilized BatterySimm in their analysis of energy storage, specifically pumped storage hydro? If not, does it plan to?

Concern: NorthWestern's assumptions for how the Pumped Hydro Portfolio was modeled.

- The 2019 Plan modeled conventional (fixed-speed) pumped storage hydro available in 2026.[20] Gordon Butte PSH will use ultra-flexible quaternary technology and be available by 2024.
- Energy storage facilities like Gordon Butte are not energy-only resources. Modeling energy storage takes a sophisticated understanding of the role it plays in a generation and transmission portfolio – the 2019 Plan should reflect this. To create the Pumped Hydro portfolio, NorthWestern added 100 MW of generic pumped hydro storage in 2026. A

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[19] https://www.ascendanalytics.com/batterysimm.html

[20] This portfolio is based upon the Current portfolio assumptions and adds 100 MW of pumped hydro in 2026. After pumped hydro, additional resources were selected using constrained ARS analysis. (10-11)

further 210 MW of additional wind was added to the portfolio because, as noted above, energy storage is not a traditional energy resource.[21] This reasoning is flawed for several reasons:

- NorthWestern is currently using DGGS, Basin Creek, Colstrip Unit 4, Cochran, Ryan, Mystic, Thompson Falls and other contracted resources to provide for their real power balancing control (RBC). If NorthWestern were to utilize Gordon Butte PSH for their RBC (a role that advanced PSH is ideally suited to play) then these other gas, hydro and coal assets would be able to be redeployed toward more traditional energy generation. By optimizing the generation fleet in this manner, 210 MW of additional wind would not be needed.
- NorthWestern is currently long at night by an estimated 50+ MW, this amount would likely increase should the utility continue to pursue additional capacity in the Colstrip Generation Station or qualifying facilities (QFs). Instead of selling this energy at off peak hours when prices are low, this long energy could and should be stored for use during the on-peak hours when energy is more valuable.
- Joining the EIM will give NorthWestern access to low-cost regional surplus generation that could be stored in the Gordon Butte PSH and deployed for peaking, ancillary services, or other flexible capacity services.

- NorthWestern identified an estimated 55-120 MW of DEC needs in their system.[22] If Gordon Butte PSH were used as a DEC resource, the energy would be stored for use later on – unlike curtailing thermal or renewable generation for this need.

  Question: What is the current estimated average amount of long night-time energy? What is the resource composition of that overproduction?

Concern: The transmission benefits of PSH were not included or valued in the modeling.

- The value that energy storage assets like Gordon Butte PSH provide to grid operators and their customers is more than just the energy and flexible capacity that were modeled by NorthWestern. The value stack of services includes transmission benefits.
- NorthWestern recently filed proposed revisions to its Montana OATT to revise its cost-based formulas for Network Integration Transmission Service, Point-To-Point Transmission Service, and certain ancillary services (FERC Docket No. ER19-1756-000).[23] This filing points to transmission related issues and needs that Gordon Butte PSH is ideally

[21] "The 100 MW pumped hydro addition offsets about 100 MW of thermal resources, but 210 MW of additional wind is also selected because pumped hydro doesn't provide for customers' energy needs."(10-16)

[22] NorthWestern Energy's 2019 Plan. Page 3-10

[23] NorthWestern Energy's proposed revisions to its Montana Open Access Transmission Tariff. FERC Docket No. ER19-1756-000

suited to address – specifically managing increased Variable Energy Resources (VERs) on its system. NorthWestern is increasingly having to recover more costs for Regulation and Frequency Response service for point-to-point exports, and for reserve capacity imposed by due to sudden large decreases of wind generator output. NorthWestern is proposing to increase its recovery rates for Schedule 1 (Scheduling, System Control and Dispatch Service), Schedule 3 (Regulation and Frequency Response), Schedule 5 (Operating Reserves – Spinning), and Schedule 6 (Operating Reserves – Supplemental) services for VERs interconnecting to its system.

NorthWestern stated the problem clearly:

"When large, sudden down-ramps of wind generation occur on NorthWestern's system, this can have a corresponding deleterious effect in NorthWestern's Area Control Error ("ACE") and place the NorthWestern ACE outside of the Balancing Authority ACE Limit of Standard BAL-001-2. This, in turn may cause NorthWestern to have to deploy flexible capacity in order to maintain compliance with Reliability Standard BAL-001-2 and to maintain system reliability. NorthWestern cannot use Regulation and Frequency Response reserves to address the large sudden down-ramps of wind generation because ***doing so would quickly exhaust NorthWestern's supply of reserves and compromise its ability to meet BA obligations. Similarly, NorthWestern cannot rely upon contingency reserves, which are used for Schedule 5 and 6 ancillary services, to respond to such down-ramps***."[24] (*emphasis added*)

These proposed changes filed at FERC indicate that there is a present and growing need for additional fast-ramping, highly flexible assets in NorthWesterns's portfolio to address its transmission needs as more and more renewable energy generation is interconnected into the grid.
Gordon Butte is designed to provide solutions and services to address this problem, in addition to all of the other valuable services it is able to provide.

Question: The 2019 Plan is focused on additions to NorthWestern's generation portfolio. How does NorthWestern address the proper valuation and considerations for technologies, like energy storage, that can provide value for both the generation and transmission sides of the utility?

Question: Does NorthWestern think that transmission benefits should be accounted for when valuing energy storage – specifically pumped storage hydro?

[24] NorthWestern Energy's proposed revisions to its Montana Open Access Transmission Tariff. FERC Docket No. ER19-1756-000. Page 30.

Concern: The NWE IRP process is not transparent.
The 2019 Plan discusses the additional interaction with the Energy Technical Advisory Committee (ETAC) during this IRP cycle.[25] While we acknowledge that the establishment of the ETAC is a step in the right direction, we do not believe that it goes far enough. Other utility's planning processes that are transparent and open to participation by all parties (throughout the planning and modeling cycle) are able to access a wider pool of expertise and leverage the process for greater buy-in by the time the draft IRP is made available.

- Many of Absaroka's 2019 Plan questions and concerns could have been considered and addressed during the resource planning process before this draft plan was issued. Instead, NorthWestern is left to defend the 2019 Plan and look at improvements in the next cycle which wastes time and resources.
- NorthWestern appropriately notes that the 2019 Plan is a planning document and that resources will be acquired through subsequent Request for Proposal (RFP) processes.[26] However, NorthWestern also notes that the 2019 Plan models will be used to evaluate RFP resources.[27]
- This is all the more reason to have a transparent and interactive planning process to address any modeling issues and/or key assumptions with this 2019 Plan prior to issuing any RFPs.

VI. Gas vs. PSH

Rate Impact to Customers

GBEP engaged an outside expert (see Attachment A) to conduct detailed modeling and analysis of the rate base impact of the Gordon Butte PSH compared to existing rate-based NorthWestern assets (Colstrip 4, Hydro Dams, Spion Kop, and the DGGS). The results show that, on an equal footing, the advanced pumped storage facility is the lowest cost choice for the utility (see Table 3).[28] Table 4 below shows the Gordon Butte PSH and its total revenue in 133 MW, 266 MW, and 400 MW capacity slices.

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[25] "NorthWestern conducted a rigorous stakeholder process for the 2019 Plan. We believe the participation of ETAC, the public and several supporting studies have helped foster a greater understanding of the needs of our retail customers, the various types of resources and the current and anticipated state of the markets…"(2-9)

26 NorthWestern Energy, 2019 Plan. Page 1-14

27 The model and modeling framework used in this plan will be used to evaluate proposals submitted during competitive solicitations and will also be used to evaluate opportunity purchases.(10-25)

28 Acelerex. Gordon Butte Rate Base Analysis. May 2019. CV for Acelerex available in Attachment A

Table 3. Comparison of existing rate-based assets versus Gordon Butte PSH.

Item	DGGS	SPION	Colstrip	Hydro	Gordon Butte
Total Revenue	$29,244,149.00	$11,683,771.0	$77,680,104.00	$142,759,244.00	$72,488,341.54
Capacity [MW]	150	40	222	448	400
Revenue $/kW-yr	$194.96	$292.09	$349.91	$318.66	$181.22

Table 4. Gordon Butte total revenue requirement by portion of facility.

Item	Gordon Butte 133 MW	Gordon Butte 266 MW	Gordon Butte 400 MW
Total Revenue	$24,102,373.56	$48,204,747.12	$72,488,341.54
Capacity [MW]	133	266	400
Revenue $/kW-yr	$181.22	$181.22	$181.22

The valuation of the cost of service was produced by a Production Cost model (developed by Acelerex). Acelerex, through key staff, are prepared to discuss these results with the utility, its consultants, the commission, and staff upon request.

Lifecycle Costs

The 2019 Plan has identified that NorthWestern will require 725 MW of new capacity, particularly flexible capacity, additions by 2025 (including reserve margins).[29] While these future flexibility needs could conceivably be met by more flexible gas units (as identified in the 2019 Plan), such as aeroderivative combustion turbines (CTs) or reciprocating engines, energy storage technologies can perform these duties much more economically because of their two-way capability – full output to full storage – effectively doubles their flexible operating range compared to nameplate capacity. For example, Gordon Butte is able to generate at 400 MW (+100%) and store energy through pumping at 400 MW (-100%) giving it a flexible operating range of 800 MW. This is in contrast to a gas-fired unit that must be up and operating at a given set-point in order to be then run up or down.

Simply put, an energy storage facility is able to be operated for flexible capacity at 200% of its nameplate, while a gas unit can only offer some fraction of its overall nameplate for the same service (see Figure 2 below).

[29] NorthWestern Energy, 2019 Plan. Page 1-3

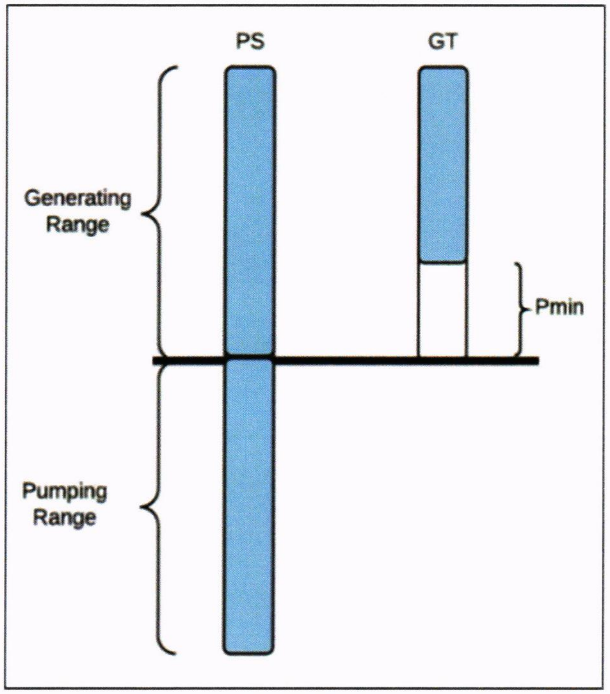


Figure 2. PSH operational range versus gas.

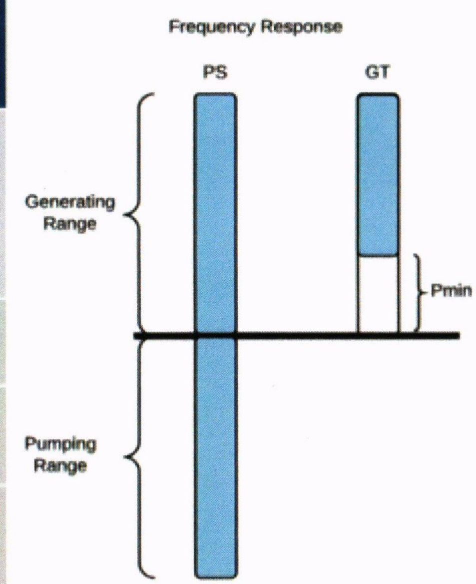
Absaroka Energy commissioned E3 Consulting to compare quaternary pumped storage hydro technology against gas peakers (aeroderivative CTs, reciprocating engines and frame CTs) for various flexible capacity products on a levelized cost per kW basis. The cost numbers used for the gas-fired units were derived from NorthWestern's 2019 Plan. Cost numbers for the quaternary PSH facility are based on GBEP's most up-to-date cost estimate figures for the Gordon Butte PSH.

The results of this study are provided as Attachment B and demonstrate that **pumped storage hydro provides these flexible capacity products at a significantly lower cost**. Some of the results of this analysis are provided below.

Flexible Capacity: Frequency Response

- Primary control - most immediate response to deviations in grid frequency
- Served by generator inertia
- Provided primarily by frequency responsive loads and synchronous generators

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Inertia of turbine and generator provides frequency response • Some markets offer fast-frequency regulation products	200%	$1,220
ICE	• Primary response requirement for generators with governor function may exist • WECC specifies droop settings for conventional generators	79%	$2,320
Aero		47%	$2,843
Frame		87%	$1,647



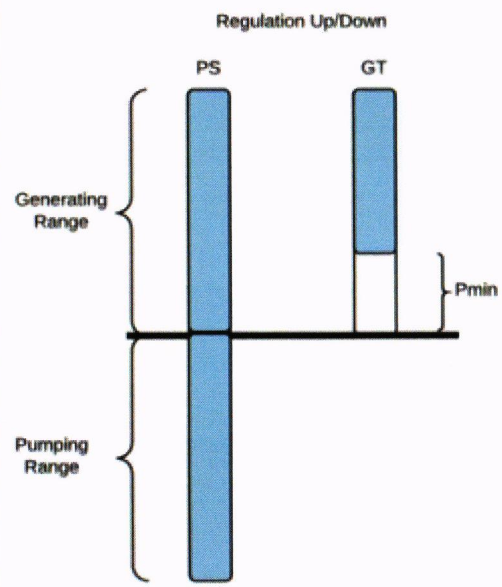
*Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]

Energy+Environmental Economics

Flexible Capacity: Regulation Up/Down

- Secondary control - occurs within seconds to minutes via automatic generation control
- Provided by generators who are online and have capacity to increase or decrease output

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Capacity to increase/decrease system output by reducing/increasing generation or load • Fast switching between modes doubles the effective range unit.	200%	$1,220
ICE	Capacity of conventional generators to provide regulation up and down is limited by ramp rate and minimum power generation levels.	79%	$2,320
Aero		47%	$2,843
Frame†		87%	$1,647



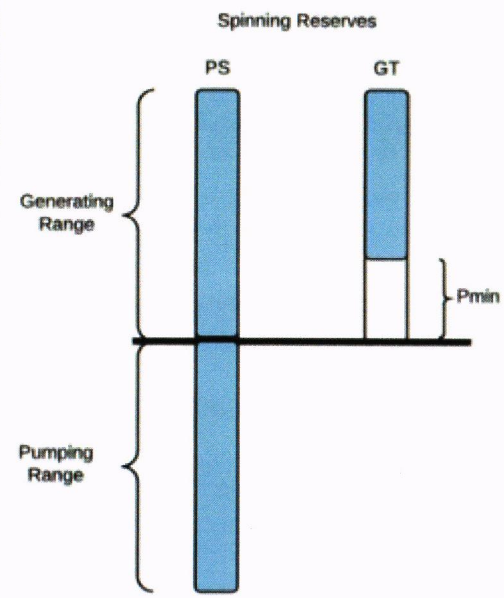
*Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]
†Frame units are not usually used for Regulation given their limited operating flexibility

Energy+Environmental Economics

Flexible Capacity: Spinning Reserves

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that are synchronized to the grid and able to ramp up within specified time frame

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Fast ramp rate and mode switching allows for fast response to operator dispatch • Unit in generation, idling, or pumping mode • Can increase/decrease load or generation • Can switch from one mode to another	200%	$1,220
ICE	• Limited by ramp rate, start-up times (hot-start)	79%	$2,320
Aero		47%	$2,843
Frame		87%	$1,647

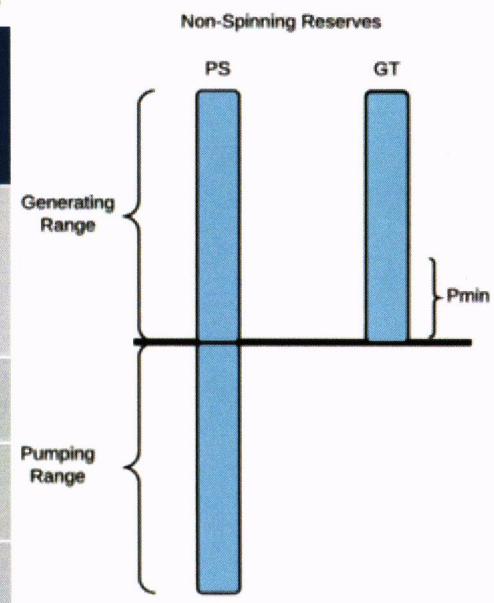


**Assuming operating state is at optimal position for providing frequency response (ex. PS pumping, GT at Pmin)*

Flexible Capacity: Non-Spinning Reserves

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that *are not necessarily* synchronized to the grid, but able to ramp up generation within specified time frame
- Required response time is slower than spinning reserves

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Unit in standby mode • If dispatched, can quickly ramp up capacity	200%	$1,220
ICE	• Capacity and participation limited by ramp rate, start up time (cold-start)	100%	$1,833
Aero		100%	$1,336
Frame		100%	$1,433



**Assuming operating state is at optimal position for providing frequency response (ex. PS pumping, GT not on)*

Energy+Environmental Economics

Additionally, gas-fired resources have minimum run times and minimum operating set-points that need to be accommodated when utilized for the minute-to-minute duties of balancing load and generation in the grid (see Figure 3 below). This includes fuel use and operational wear and tear from multiple daily cycling.

Assumptions

		Quaternary Pumped Storage	Natural Gas Simple Cycle†		
Operating Characteristic	Units	Pumped Storage Hydro (PSH)*	Internal Combustion Engine (ICE)	Aeroderivative Combustion Turbine (Aero)	Frame Combustion Turbine (Frame)
Min Run Time	Hours	not reported	1	8	8
Min Down Time	Hours	not reported	1	7	7
Operating Range	[min –max, as % of capacity]	-100% (pumping) – +100% (generating)	21%-100%	53%-100%	13%-100%

Figure 3. Minimum run time, minimum down time, and operating range for flexible resources.

Regulation at Night – Regulation During Day

In addition to having different impacts on overall portfolio capital costs, flexible gas-fired units and PSH will perform differently in system operations. Utility resource planning processes frequently rely upon hourly production cost modeling with some nominal amount of capacity set aside as a proxy for short-term regulation and balancing requirements. This approach may be sufficient for typical resource planning studies, but it is inadequate for accurately evaluating different flexible capacity resources.

To properly evaluate different flexible capacity options, it is necessary to perform detailed modeling that accounts for variations in performance for competing technologies. The following general examples are given to illustrate the differential in operational capabilities under various system conditions:

<u>Example 1 – Morning Load Pickup Hour</u>

Consider a load pickup hour in the morning where load is expected to increase by 150 MW over the course of the hour.

- This load ramp could be met by 150 MW of RICE (ignoring minimum load requirements) ramping from 0 to 150 MW. Assuming a uniform load ramp, the ICE units will produce 75 MWh during this hour.[30] This generation will likely be out-of-market given the heat rate for RICE units.

[30] These suggested numbers are for demonstration only. We would appreciate the opportunity to properly analyze these issues with data from actual operations.

- Alternatively, this 150 MW load ramp could also be met 75 MW of PSH ramping from 75 MW pumping to 75 MW generating. The PSH would produce no net out-of-market energy over this hour.

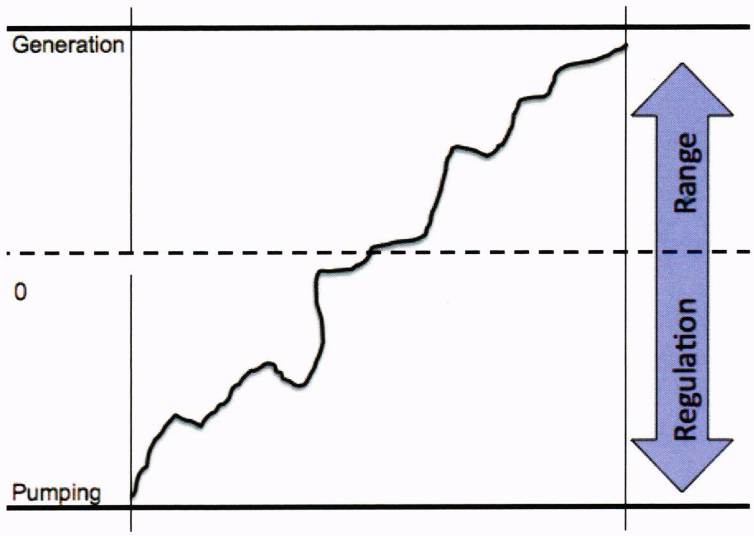


Figure 4. PSH Load Regulation – Morning Load Ramp

Example 2 – Nighttime Load Hour

Consider a nighttime hour when load is expected to be relatively steady and assume that the system operator needs 25 MW of regulation up and 25 MW of regulation down to deal with load variability and uncertainty.

- This need could be met by running RICE units at an expected level of 25 MW (again ignoring minimum load requirements) to leave room to regulate down if the load does drop off. The expected generation from the RICE units would be 25 MWh (plus any minimum load requirement). Again, this generation will likely be out-of-market, especially during nighttime hours, given the heat rate for RICE units.
- This same need could be met by 75 MW of PSH operating at an expected level of 50 MW pumping to leave room for additional pumping if the load does drop off. Instead of producing out-of-market energy, the PSH would be expected to store 50 MWh of energy that would be available at attractive prices during nighttime hours.[31]

[31] The hydro fleet recently reacquired by NWE is primarily a run-of-river hydro and therefore cannot be turned down in off-peak hours. During nighttime hours, NWE's portfolio is long by approximately 50 MW. This energy could be utilized by the Gordon Butte PSH to regulate in pumping mode at night.

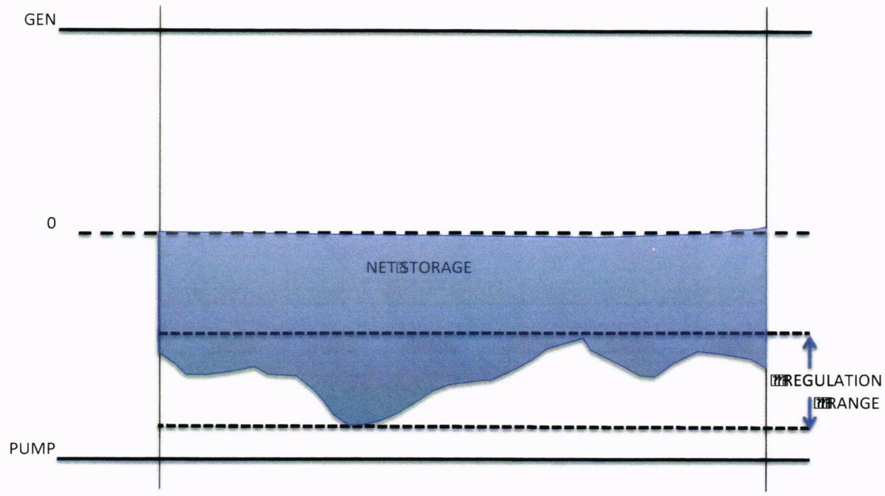


Figure 5. PSH Load Regulation – Typical Nighttime Hour

Example 3 – High Wind Hour

Consider an hour when NWE's wind fleet is operating at maximum output resulting in a need for 150 MW of regulation up in case the wind drops off.

- This need could be met by 150 MW of RICE on-line and ready to ramp up if the wind does fall off.
- The same need could be met by 75 MW of PSH set to 75 MW pumping and ready to ramp up to 75 MW generation if the wind does fall off. If the wind does not fall off, the PSH would store 75 MWh of wind energy that would likely be in excess of NWE's needs.

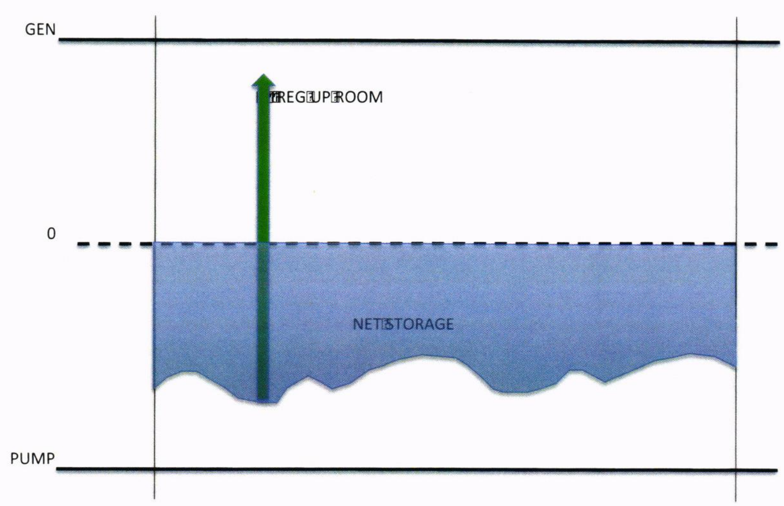


Figure 6. PSH Wind Regulation –High Wind Hour

These examples demonstrate that the operational impacts of RICE (or other flexible gas units) and PSH are different and should be treated as such. To quantify this difference, we feel it is essential to conduct detailed production cost modeling that is sensitive to how ancillary service needs vary under a full range of system conditions.

Natural Gas, The Next Stranded Asset

A recent report by the Rocky Mountain Institute, highlights some of the risks associated by the current efforts to build out the natural gas generation fleet.[32] The current fleet of thermal power plants is aging, with over half of this fleet being more than 30 years old and expected to reach retirement age by 2030. Currently, technology advances and low natural gas prices have led to a rush to gas; utilities and independent power plant developers announcing plans to invest over $110 billion in new gas-fired power plants along with $32 billion in proposed gas delivery infrastructure through 2025.[33]

However, natural gas power plants are not the only generation assets capable of replacing the retiring thermal fleet. Renewable energy generation, such as wind and solar, prices have fallen precipitously in price over the past 10 years, and new fast-acting pumped storage hydro technologies have emerged that can offer firm, dispatchable energy products that provide the same service as the coal plants, often at a net cost saving.

The price of these "clean energy portfolios" (VER + Storage) are expected to continue to decline over the next decade. RMI's analysis revealed that across a wide range of their case studies, regionally specific clean energy portfolios already are outcompeting proposed gas-fired generators, and/or threaten to erode their revenue within the next 10 years. The investments made in gas power plants in addition to the additional investments needed in the gas delivery system **are already at risk of becoming stranded assets**.

In addition, natural gas fuel prices, while currently at low levels, will likely go up and become increasingly volatile. Natural gas prices are a function of supply and demand and subject to volatility based on stockpile levels, infrastructure conditions and weather.[34]

NorthWestern and Montana's Public Service Commission should avoid the risk of locking in significant ratepayer costs for new gas-fired resources that are increasingly uneconomic, and carefully consider alternatives to new gas generation before allowing recovery of costs in rates.

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[32] M. Dyson, J. Farbes, and A Engel. The Economics of Clean Energy Portfolios: How Renewable and Distributed Energy Resources Are Outcompeting and Can Strand Investment in Natural Gas-Fired Generation. Rocky Mountain Institute, 2018. www.rmi.org/insights/reports/economics-clean-energy-portfolios

[33] M. Dyson, et. al. Page 10

[34] https://www.eia.gov/energyexplained/index.php?page=natural_gas_factors_affecting_prices

https://www.cnbc.com/2019/01/14/natural-gas-prices-spike-13-percent-on-forecasts-for-long-severe-cold.html

More information on this may be found at: www.rmi.org/insights/reports/economics-clean-energy-portfolios.

Fuel Supply

New gas fired resources will need costly upgrades to the gas delivery system that, outside of the RICE additions at DGGS,[35] appear to be unquantified in the 2019 Plan. This fuel supply is subject to volatility in the markets, disruptions from gas line failures (as Puget Sound Energy recently experienced),[36] exposure to future carbon pricing risk in the future (see Section III above). To account for these risks, NorthWestern has proposed that on-site alternative fuel such as diesel will be available to make up for shortcomings in the months when natural gas is unavailable or prioritized for uses like home heating on cold days above the generation of energy.

In contrast, the Gordon Butte PSH will draw from the regional grid via the Project's interconnection to the Colstrip Transmission System for its "fuel supply." This supply will therefore be whatever the least cost energy from the grid is available at any given time from the multiple interconnected energy generation sources (wind, coal, gas, hydro, solar, etc.) to recharge the upper reservoir. This fuel supply is sensitive to regional electricity markets. As we look to the future, we see that generation sources such as regional wind energy generation, solar production on the West Coast and springtime Columbia River hydropower continue to be in oversupply, depressing regional energy prices – and this trend will only increase over time. These downward pricing trends will be captured by the Gordon Butte PSH, driving down fuel supply costs for the facility.

There will be an estimated 15% efficiency loss between the generation and pumping energy. However, this round-trip efficiency penalty is more than offset by out-of-market energy costs incurred when operating other technologies such as gas-fired units for regulation and load following.

Because of the diversity of generation sources in the grid fuel supply for the Gordon Butte PSH carries no risk of disruption and minimal price volatility to supply flexible capacity and ancillary services for NorthWestern.

Case Study – Looking at Wind and PSH in NWE's System

GBEP has investigated the ability of advanced PSH to be paired with VERs to provide firmed, dispatchable on peak energy.

To visualize and understand the behavior and value of PSH technology, GBEP developed a basic modeling system to simulate the operation and effects of a pumped storage system paired with generation from renewable resources. The model allows the user to enter 10-minute production

[35] RICE Additions
[36] https://www.seattletimes.com/seattle-news/puget-sound-energy-asks-customers-to-conserve-power-after-canadian-natural-gas-pipeline-ruptures/

data and specify the physical parameters (size, duration, efficiency, etc.) of the storage facility as well as provide operational instructions (target output levels, pumping/generating preferences, etc.) and market conditions (peak hours, excess power availability, etc.) to influence and fine-tune the "decision-making" of the pumped storage facility.

Using this tool, GBEP evaluated the interaction of a 1/3 portion of the Gordon Butte Pumped Storage facility (134 MW turbine and 134 MW pump unit) paired with a single 230 MW wind farm located in central Montana. Actual 10-minute wind data was used to run the model. For off-peak energy storage, the simulated storage facility was allowed to make use of the utility's "long" resources at night (up to 75 MW)[37] in addition to the energy produced by the 230 MW wind farm. GBEP then instructed the program to calculate capacity factors during peak hours. The table below compares the average hourly generation and capacity factors of the wind farm alone to those of the combined wind+PSH system.

Table 5. Results of wind and PSH on-peak capacity factor modeling.

Hour:	Wind Production (GWh):	Wind Capacity Factor (%):	Wind+PSH Production (GWh):	Wind+PSH Capacity Factor (%):
8	34.11	40.63%	68.32	81.38%
9	35.46	42.24%	68.83	81.99%
10	37.76	44.97%	69.93	83.30%
11	39.62	47.19%	71.08	84.67%
12	41.21	49.08%	70.79	84.32%
13	41.43	49.35%	64.20	76.48%
14	42.18	50.25%	61.09	72.77%
15	41.55	49.50%	57.81	68.86%
16	40.83	48.63%	54.90	65.40%
17	40.27	47.97%	53.25	63.44%
18	38.87	46.30%	50.85	60.57%
19	36.82	43.86%	48.41	57.67%
20	34.73	41.36%	44.81	53.38%
21	32.59	38.82%	41.56	49.51%
ON-PEAK AVERAGES	**38.39**	**45.73%**	**58.99**	**70.27%**

These results clearly show the value that PSH will add to renewables and NWE's system; demonstrated by the significant boost that a pumped storage system provides during critical peak hours. This, in effect, creates a dispatchable and completely renewable generation resource.

37 The model assumes 75 MWs of "long" opportunity at night based on public statements by NorthWestern; it is anticipated that this number will grow in the future as more wind is interconnected in Montana.

For comparison, the capacity factors of the real-world utilization of other types of generation resources are as follows:

- Coal: 56.15% (6-year average)
- Natural Gas - Combined Cycle: 52.8% (6-year average)
- Natural Gas – Peaker: 7.3% (6-year average)[38]
- Traditional Hydro: 42.08% (11-year average)[39]

What is not shown in the model is using the allocated share of Gordon Butte to not only shape and dispatch the wind, but to also provide regulation duty at the same time.[40] To assess this opportunity we would bias the model to use the PSH to regulate on the pump side at night and switch to regulating on the generation side during the day. This would likely reduce slightly the on-peak capacity output of the wind as the PSH units moved up and down in regulation mode, but at a starting point of an on-peak capacity factor of 70%, the diminution will likely not invalidate the point. GBEP would like the opportunity to work with the utility to better model the PSH facility and its interactions with VER to quantify the cost/benefit opportunities of using a slice of the PSH for NWE's system. GBEP is confident that the results would be substantial.

Additionally, it is important to note that the model is limited in its ability to fully quantify the benefits that will be provided by a pumped storage facility.[41] GBEP would welcome the opportunity to work directly with NorthWestern to more holistically model the Gordon Butte PSH in their system to see how the facility is able to provide value to NWE's system, and at the same time, solve the issues identified in the 2019 Plan.

VII. Gordon Butte PSH

Technology Overview - Quaternary

PSH accounts 95% of the current existing energy storage asset in the United States. There are 40 currently operational PSH facilities that provide an estimated 25 GW of storage. However, the

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[38] https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_a

[39] https://www.energy.gov/sites/prod/files/2018/04/f51/Hydropower%20Market%20Report.pdf

[40] This potential configuration was discussed with David Gates while at the utility and before his unfortunate death – that Gordon Butte could provide regulation services and allow, once Gordon Butte was on-line, what was then the Mill Creek project to evolve to a peaker or combined cycle facility; in fact, Gordon Butte could provide this resource for less money than ratepayers are charged for DGGS; again this does not take into account the other opportunities and risk mitigation benefits illustrated in part in the Case Study

[41] For instance, the simulation developed by GBEP relies on a relatively small amount of input data (wind farm production, target values, and facility parameters) and does not accommodate additional data such as forecasted weather or transmission system data or variations in daily load patterns. The model also does not account for the PSH's ability to perform other services such as regulation and ancillary services and does not account for any regional resource diversity.

fleet of domestic PSH facilities are not responsive enough to currently compete against other flexible capacity technologies, such as fast-ramping gas units and batteries. These PSH plants were largely built in the 1970's and 1980's and were paired with large thermal generators such as coal and nuclear. The equipment used was conventional fixed-speed pump/turbine units. Over the past two decades, a new class of PSH equipment has been developed and successfully deployed throughout Europe, Asia, and around the world.

The quaternary technology that the Gordon Butte facility will utilize is the fastest responding pumped hydro technology available today for grid services.[42] This configuration will consist of separate pumps and turbines, each with a dedicated 134 MW motor and 134 MW generator, respectively. The equipment will also be connected in a hydraulic short circuit - basically a hydraulic loop connecting the turbine and the pump utilizing the lower reservoir. This equipment configuration will allow the facility to both pump and generate at the same time and seamlessly switch from pumping to generating and back again (including cold-start) at an estimated 20+ MW/sec.

The quaternary equipment configuration will preserve the basic components of the Project's previous ternary configuration; the turbine and pump will be separated, the ability to operate independently of one another, and the hydraulic short circuit. The quaternary PSH also improves upon the mode-switching speeds, start and shutdown times, and the +/- 100% operational range of the facility – all for a lower unit cost.

Figure 7 below is a 24-hour operational profile of a single unit at the KOPS II Pumped Storage Hydro Facility in Austria. This facility has developed equipment with a similar operation range and capability as the Quaternary configuration planned for Gordon Butte PSH. KOPS II has 3 equally-sized units with an installed capacity of 175 MW of generation and 150 MW of pumping. This figure shows the rapid intra-hour mode changes from pumping to generating, as these Ternary units "absorb" load and generation fluctuations on the grid, keeping it stable and operational. The plant is able to move very quickly in either direction. This mirrors the intermittent behavior of variable energy generation profiles, particularly the wind.

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[42] Z. Dong, J. Tan, E. Muljadi, R. Nelms, M. Jacobson. "Modeling of Quaternary Pumped Storage Hydropower (Q-PSH) for Power Systems Studies" *IEEE Transactions on Energy Conversion*. 2019

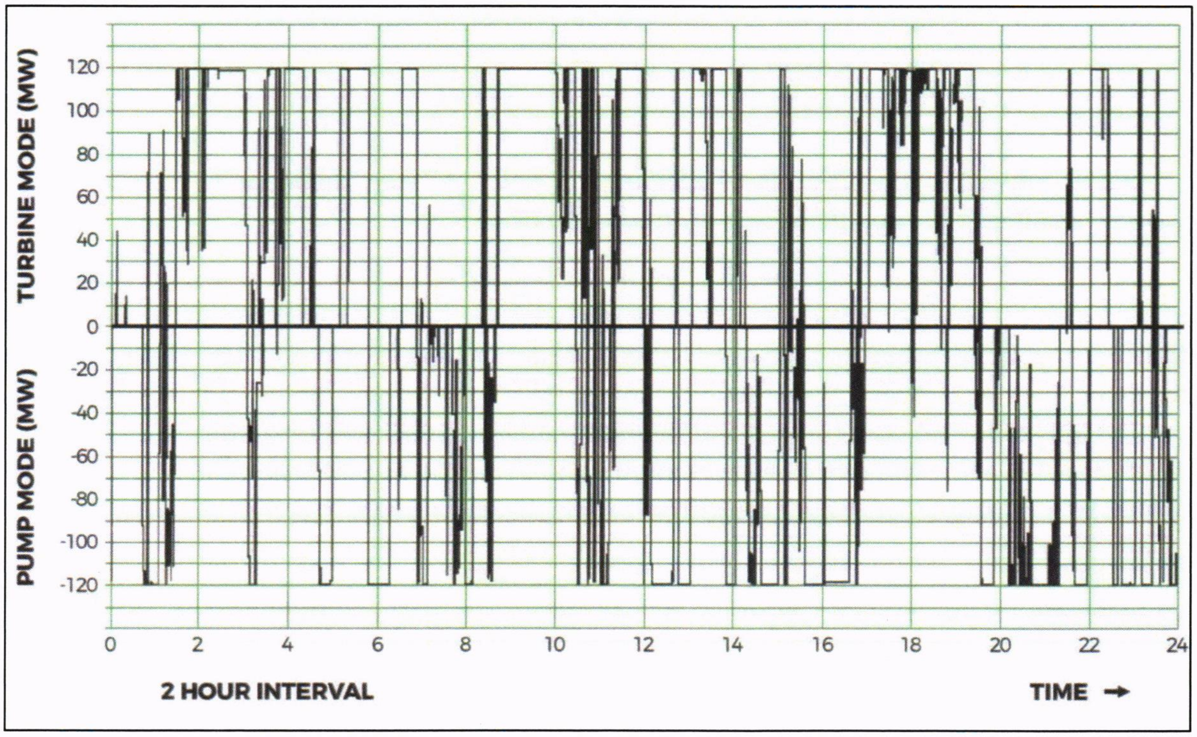

Figure 7. 24-hour operational profile of a single unit at Kops II

Quaternary PSH can provide higher storage capacity with minimal maintenance over a 50+ year lifetime. Older conventional pumped storage plants could only operate in either generating mode or pumping mode. The transition between these two modes would require the unit to come to a full stop, dewater the unit, then restart it in the opposite direction. The fast response time and operational range of the modern quaternary units are a result of their ability to operate both the pump-motor and the turbine-generator simultaneously.

This feature enables Quaternary to provide fast acting response to power system operational changes that are important to system reliability.

At 400 MW of nameplate capacity, Gordon Butte PSH will be able to offer 800 MW of fast acting regulation capacity (the ability to generate 400 MW and pump 400 MW) and switch from pumping to generating and back again at approximately 20+ MW/sec. Again, the utility is able to acquire or contract for all or a portion of the facility's capacity.

The speed at which modern quaternary units can operate makes the Gordon Butte PSH a large and robust rechargeable "battery" that is able to provide storage over different intervals of time including: hourly (energy arbitrage, renewable integration, ramping, peaking / peak shaving), sub-hourly for ancillary services, and fast acting (frequency control, regulation and essential reliability services).[43]

[43] https://gordonbuttepumpedstorage.com/project-overview/project-video/

VIII. Energy Storage Projects Not Fitting Well into Utility Resource Planning

In October of 2017, the Washington UTC issued the *Report and Policy Statement on Treatment of Energy Storage Technologies in Integrated Resource Planning and Resource Acquisition.*[44] GBEP believes that this report correctly identifies and clearly articulated the historic problems of evaluating energy storage, particularly utility-scale projects such as the Gordon Butte PSH, through the traditional utility planning process. The reality is that large, capital-intensive projects provide value and benefit that is spread across the generation, transmission and distribution networks of a utility company, and offer products that not properly accounted for during the planning and acquisition processes.

The Washington UTC succinctly summed up the issue: "Historically, utility resource planning has taken place within the independent silos of generation, transmission, and distribution. Energy storage can act in any one of those functions, but the challenging corollary is that to generate sufficient benefits to offset its cost, it will most likely be required to act in more than one function. In a planning regime that narrowly looks at the functions separately, energy storage is unlikely to appear cost effective through the lens of any single function, which appears to be one likely reason that past IRPs have not determined energy storage technologies should be included in a utility's resource mix."

GBEP endorses the following guidelines outlined in the October 2017 Washington UTC report and encourages NorthWestern to ensure that energy storage is properly evaluated during the anticipated upcoming Request for Proposals in 2019 and beyond.

- The many value streams provided by energy storage should be stacked to provide a holistic representation of benefits.
- Energy storage should be credited for benefits across generation, transmission and distribution sides of the utility's network.
- Energy storage should be modeled on a sub-hourly basis to better capture the operational benefits of instantaneously available bulk energy storage.
- NorthWestern should allow stakeholders access to their modeling assumptions and results and recommend alternative scenario recommendations, if warranted.
- NorthWestern and the Montana PSC should consider alternative procurement strategies for large energy storage facilities that are not properly valued in a traditional utility procurement process.

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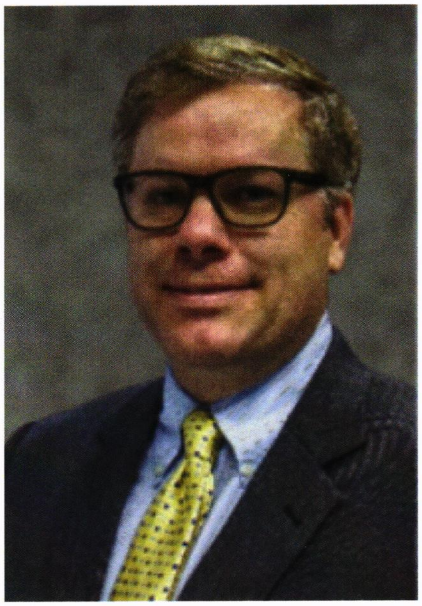
[44] Washington Utilities and Transportation Commission, Modeling Energy Storage: Challenges and Opportunities for Washington Utilities, May 2015. https://www.utc.wa.gov/docs/Pages/DocketLookup.aspx?FilingID=U-151069

Attachment A

Acelerex Key Personnel

Randell Johnson, PE PhD



PRESIDENT & CEO
ACELEREX

Dr. Randell Johnson's PE career spans 25 years across 70 countries to deliver grid optimizations, power and energy market risk analysis, M&A guidance, as well as planning and strategy for utilities, developers, investors, and governments. Altogether, the energy infrastructure projects Dr. Johnson has advised are valued at a cumulative $35 billion. Furthermore, Dr. Johnson led modelling efforts for the ground-breaking *Massachusetts State of Charge Report* and spearheaded analytics for *NYSERDA Energy Storage Road Map*, in addition to contributing to several other major energy storage studies which have not yet become public.

Dr. Johnson currently leads Acelerex as President and CEO. Acelerex is an independent consulting and software firm providing data analytics services with specialties in energy storage and grid studies. Acelerex provides these services for a range of clients including utilities, governments, grid operators, regulatory commissions, developers, equipment makers and others. Headquartered at the Cambridge Innovation Center (CIC) in Boston, Acelerex also has a Houston office.

Dr. Johnson earned both his PhD and Masters of Engineering from Rensselaer Polytechnic Institute (RPI) in Upstate New York, receieved his Masters of Science in Quantitative Finance from Cass Business School in London, and specialized in Gas and Electric Utility Corporate Finance at UConn School of Business.

Attachment B

E3 Analysis *Quaternary Pumped Storage Flexible Capacity Assessment*

Energy+Environmental Economics

Quaternary Pumped Storage Flexible Capacity Assessment

Prepared for Absaroka Energy in response to NorthWestern Energy's 2019 Electricity Supply Resource Procurement Plan

4/29/2019

Arne Olson, Partner
Doug Allen, Managing Consultant
Vivian Li, Associate

Analysis Description

+ **Absaroka Energy LLC asked E3 to compare their quaternary pumped storage technology to conventional resources in terms of their ability to provide "flexible capacity"**
  - Conventional resources considered: Internal Combustion (Reciprocating) Engine, Frame Combustion Turbine, Aeroderivative Combustion Turbine
+ **Flexible capacity does not have a specific definition, so we have looked at each resource's ability to provide**
  - System capacity
  - Ancillary Services

Flexible Capacity Cost Comparison

Nameplate Capacity	Frequency Response	Regulation Up/Down	Spinning Reserves	Non-spinning Reserves
Ability to provide capacity during peak events and contribute to required reserve margins	Most immediate response to deviations in grid frequency served by generator inertia	Provided by generators that are online and have capacity to increase or decrease generation output or load consumption (pumping)	Provided by units that are synchronized to the grid and, upon dispatch, able to ramp up within specified time frame	Provided by units that need not be synchronized to the grid, but are able to ramp up generation within specified time frame upon dispatch

Capital Cost Analysis
$\text{Product Specific Cost}\left(\frac{\$}{\text{kW}}\right) = \frac{\text{Capital Costs}^{*}\ (\frac{\$}{\text{kW}})}{\text{Product Specific Usable Capacity (\%)}}$

** Capital costs considered in this analysis include infrastructure costs as detailed in the 2015 NWE Electricity Supply Resource Procurement Plan*

Cost Comparison

+ **For each capacity product, we describe the ability of the different generating technologies to supply that product**
+ **We then calculate the product-specific cost per kW by technology**
  • Allows for more balanced comparison of "capacity cost" than a simple $/kW installed cost
+ **This comparison focuses on *costs per unit of flexible capacity only*, and does not include an analysis of potential revenues**

Comparison Scope

+ **This analysis looks solely at the comparative capital costs (per installed kW) of the different technologies**
  - Accounts for each technology's ability to provide different capacity services
  - Does not account for
    - Fuel / Variable Operating costs
    - Revenues from participation in energy markets
    - Potential impacts of carbon price or air quality operating restrictions
    - Carbon benefits of absorbing renewable overgeneration for later use

Assumptions

Operating Characteristic	Units	Quaternary Pumped Storage: Pumped Storage Hydro (PSH)*	Natural Gas Simple Cycle†: Internal Combustion Engine (ICE)	Natural Gas Simple Cycle†: Aeroderivative Combustion Turbine (Aero)	Natural Gas Simple Cycle†: Frame Combustion Turbine (Frame)
Technology	-	Ternary Unit	Warsila 18V50SG	GE LMS100	GE 7EA
Capacity	MW	150	18	50	50
Capital Costs◊	2018$/kW	$2,439	$1,833	$1,336	$1,433
Ramp Rate	MW/min	300	4	10	4
Start Time	min	0.4 – 1.5	not reported	not reported	not reported
Shut-down Time	min	2$^{\Delta}$	not reported	not reported	not reported
Min Run Time	Hours	not reported	1	8	8
Min Down Time	Hours	not reported	1	7	7
Operating Range	[min –max, as % of capacity]	-100% (pumping) – +100% (generating)	21%-100%	53%-100%	13%-100%

** Data provided by Absaroka*

† All Data taken from New Resources Cost Summary for Western MT section of the NorthWestern Energy 2019 Electricity Supply Resource Procurement Plan

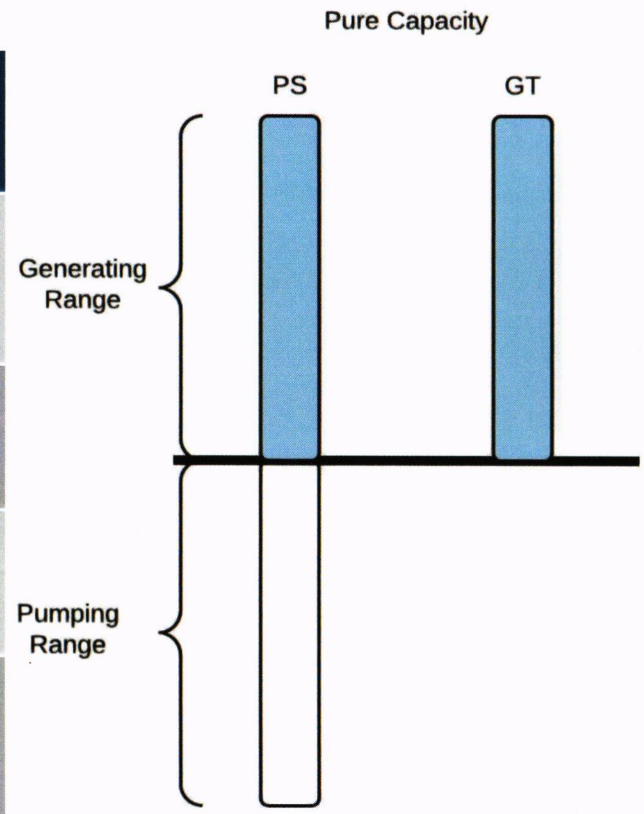
Δ Assuming "transfer mode" as the final state of rest

◊ Includes "Infrastructure" costs as described in NWE's Procurement Plan

Nameplate Capacity

- Usable capacity provided by the unit (as listed in the NWE Electricity Supply Resource Procurement Plan)
- Reflects the unit's contribution to reserve margins / system capacity
- Amount of capacity available to meet peak capacity needs

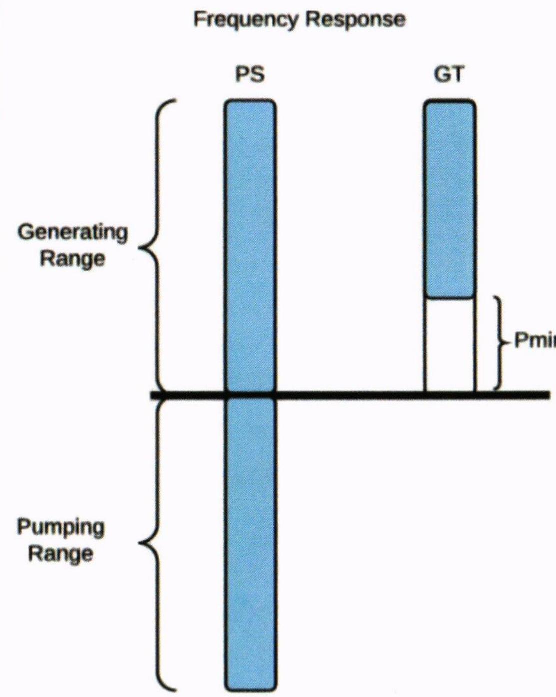
	Capacity Assumptions	Capital Costs (2018 $/kW)
PSH	Generation rated power = 150 MW Pumping rated load = 150 MW	$2,439
ICE	Generation rated power = 18 MW	$1,833
Aero	Generation rated power = 50 MW	$1,336
Frame	Generation rated power = 50 MW	$1,433



Flexible Capacity: Frequency Response

- Primary control - most immediate response to deviations in grid frequency
- Served by generator inertia
- Provided primarily by frequency responsive loads and synchronous generators

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Inertia of turbine and generator provides frequency response • Some markets offer fast-frequency regulation products	200%	$1,220
ICE	• Primary response requirement for generators with governor function may exist • WECC specifies droop settings for conventional generators	79%	$2,320
Aero		47%	$2,843
Frame		87%	$1,647

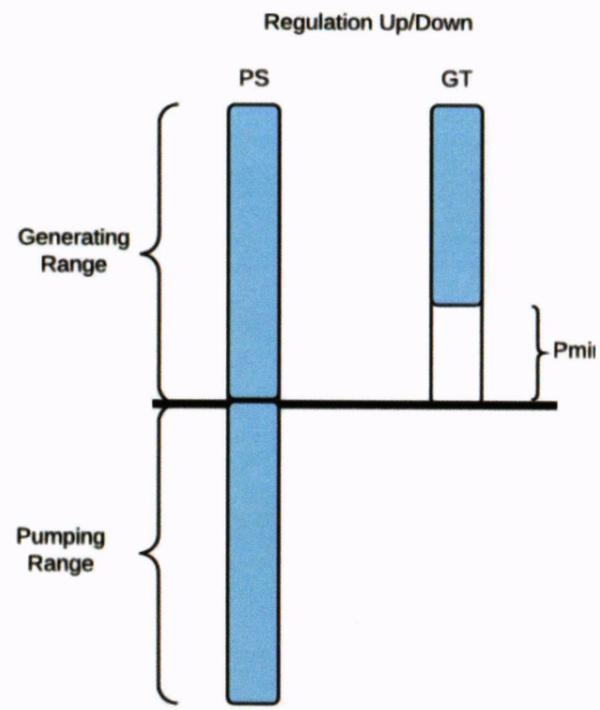


**Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]*

Flexible Capacity: Regulation Up/Down

- Secondary control - occurs within seconds to minutes via automatic generation control
- Provided by generators who are online and have capacity to increase or decrease output

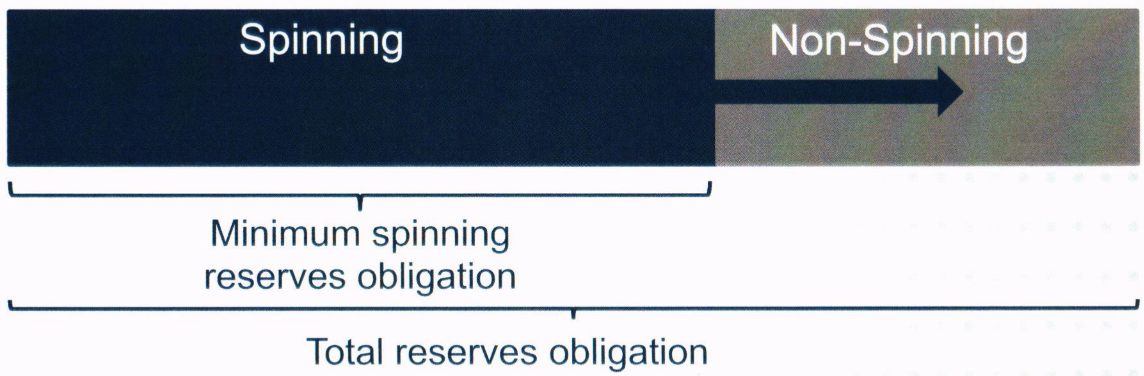
	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Capacity to increase/decrease system output by reducing/increasing generation or load • Fast switching between modes doubles the effective range unit.	200%	$1,220
ICE	Capacity of conventional generators to provide regulation up and down is limited by ramp rate and minimum power generation levels.	79%	$2,320
Aero		47%	$2,843
Frame†		87%	$1,647



*Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]
†Frame units are not usually used for Regulation given their limited operating flexibility

Spinning vs. Non-Spinning Reserves

- **Spinning/Non-spinning reserves are used to meet the same operating reserve obligation**

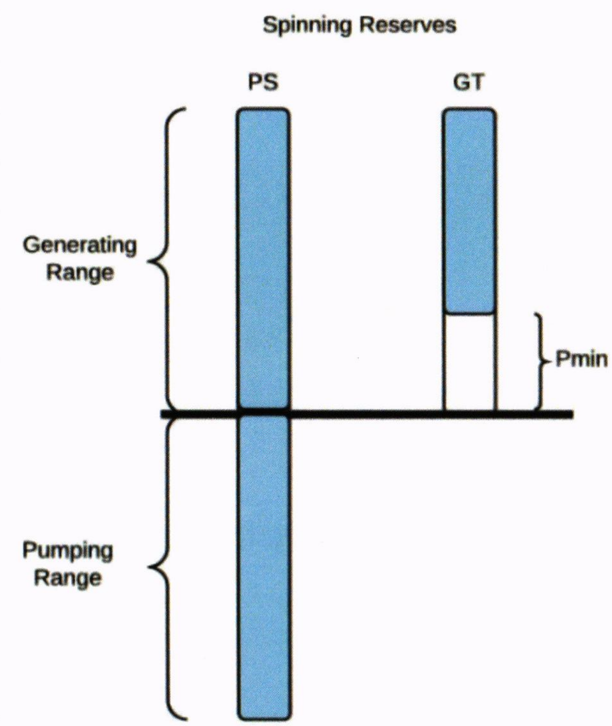


- **Fast response of ternary pumped storage units allows for provision of either spinning or non-spinning reserves, even when in charging mode**

Flexible Capacity: Spinning Reserves

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that are synchronized to the grid and able to ramp up within specified time frame

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Fast ramp rate and mode switching allows for fast response to operator dispatch • Unit in generation, idling, or pumping mode • Can increase/decrease load or generation • Can switch from one mode to another	200%	$1,220
ICE	• Limited by ramp rate, start-up times (hot-start)	79%	$2,320
Aero		47%	$2,843
Frame		87%	$1,647

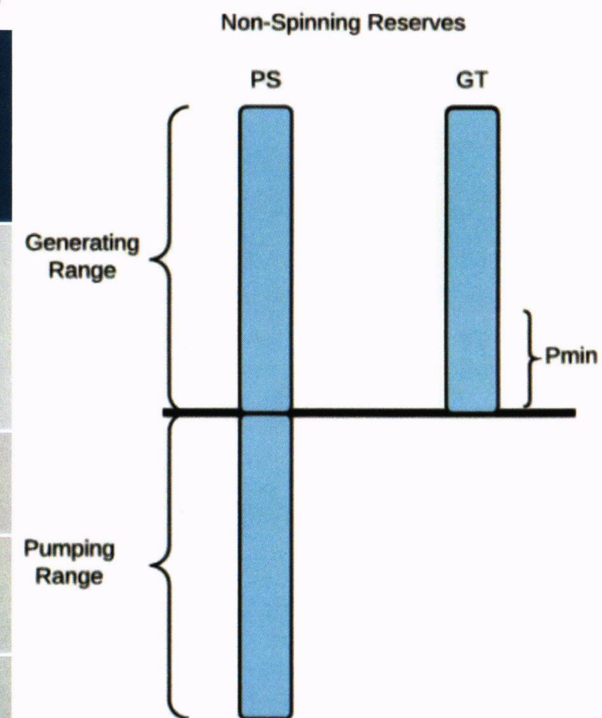


Assuming operating state is at optimal position for providing frequency response [ex. PS pumping, GT at Pmin]

Flexible Capacity: Non-Spinning Reserves

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that *are not necessarily* synchronized to the grid, but able to ramp up generation within specified time frame
- Required response time is slower than spinning reserves

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 $/kW)
PSH	• Unit in standby mode • If dispatched, can quickly ramp up capacity	200%	$1,220
ICE	• Capacity and participation limited by ramp rate, start up time (cold-start)	100%	$1,833
Aero		100%	$1,336
Frame		100%	$1,433



Assuming operating state is at optimal position for providing frequency response [ex. PS pumping, GT not on]

Additional Flexible Capabilities

Operating Characteristic	Gordon Butte Pumped Storage Quaternary Unit	Aeroderivative CT	Frame CT	ICE
Additional cost for each start	Minimal	Yes	Yes	Yes
Estimated median cold start cost*	n/a	$32/MW	$103/MW	Not provided
Can absorb overgeneration?	Yes	No	No	No
Black start?	Yes	Yes**	Yes**	Yes**

*Intertek APTECH (2012). Power Plant Cycling Costs. http://wind.nrel.gov/public/wwis/aptechfinalv2.pdf

**Siemens (2006). Black Start Studies. https://w3.usa.siemens.com/datapool/us/SmartGrid/docs/pti/2006June/Black_Start_Studies.pdf

Conclusions

+ **Compared to the conventional resources described in NWE's 2019 Electricity Supply Resource Procurement Plan, Quaternary Pumped Storage can provide the following services at a cheaper per-kW installed price:**
  - Frequency Response
  - Regulation Up / Down
  - Spinning Reserve
  - Non-Spinning Reserve
+ **Beyond the ability to provide flexible and peak capacity considered here, this analysis does not reflect a pumped storage facility's ability to store energy for use later, which enables**
  - Absorption of overgeneration
  - Arbitrage of energy price spreads
  - Increased transmission system utilization

Assumptions

		Quaternary Pumped Storage	Natural Gas Simple Cycle†		
Operating Characteristic	Units	Pumped Storage Hydro (PSH)*	Internal Combustion Engine (ICE)	Aeroderivative Combustion Turbine (Aero)	Frame Combustion Turbine (Frame)
Min Run Time	Hours	not reported	1	8	8
Min Down Time	Hours	not reported	1	7	7
Operating Range	[min –max, as % of capacity]	-100% (pumping) – +100% (generating)	21%-100%	53%-100%	13%-100%
Min Run Time	Hours	not reported	1	8	8
Min Down Time	Hours	not reported	1	7	7
Operating Range	[min –max, as % of capacity]	-100% (pumping) – +100% (generating)	21%-100%	53%-100%	13%-100%

DRAFT RESULTS - FOR DISCUSSION ONLY